



Discharge comparison measurements, ice covered rivers

Propeller current meter, QLiner, StreamPro SxS

Norwegian Water Resources and Energy Directorate
(NVE)

Kristoffer Dybvik
NHC 2008



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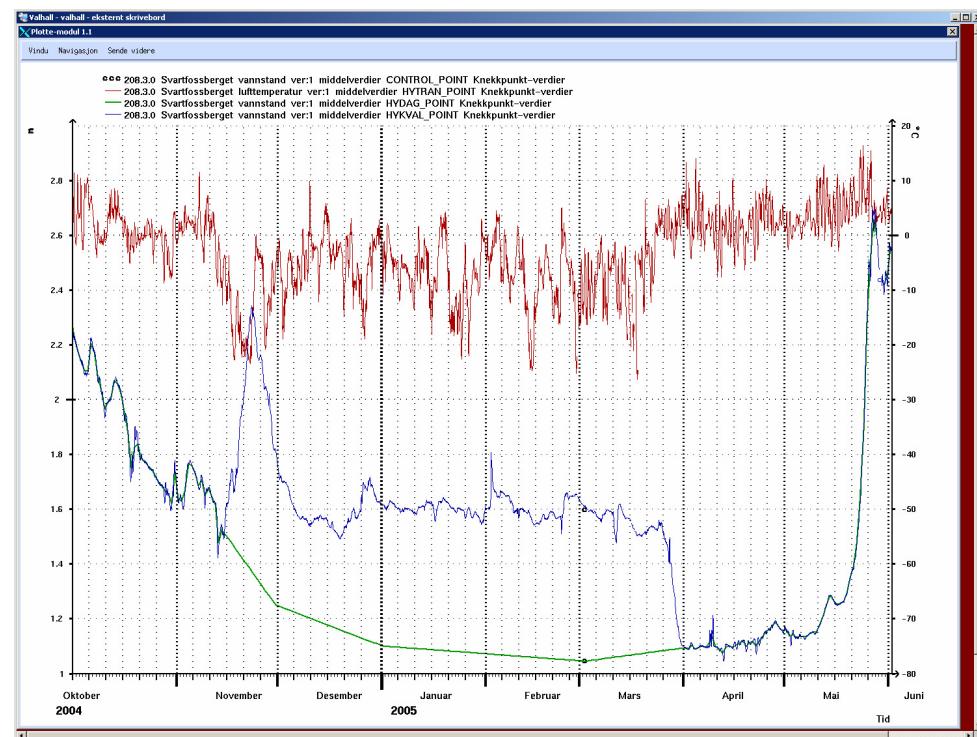
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Why measure on ice covered rivers?

- We usually measure stage and calculate discharge
- Stage/discharge rating not valid when ice
- Must measure discharge to correct discharge time series





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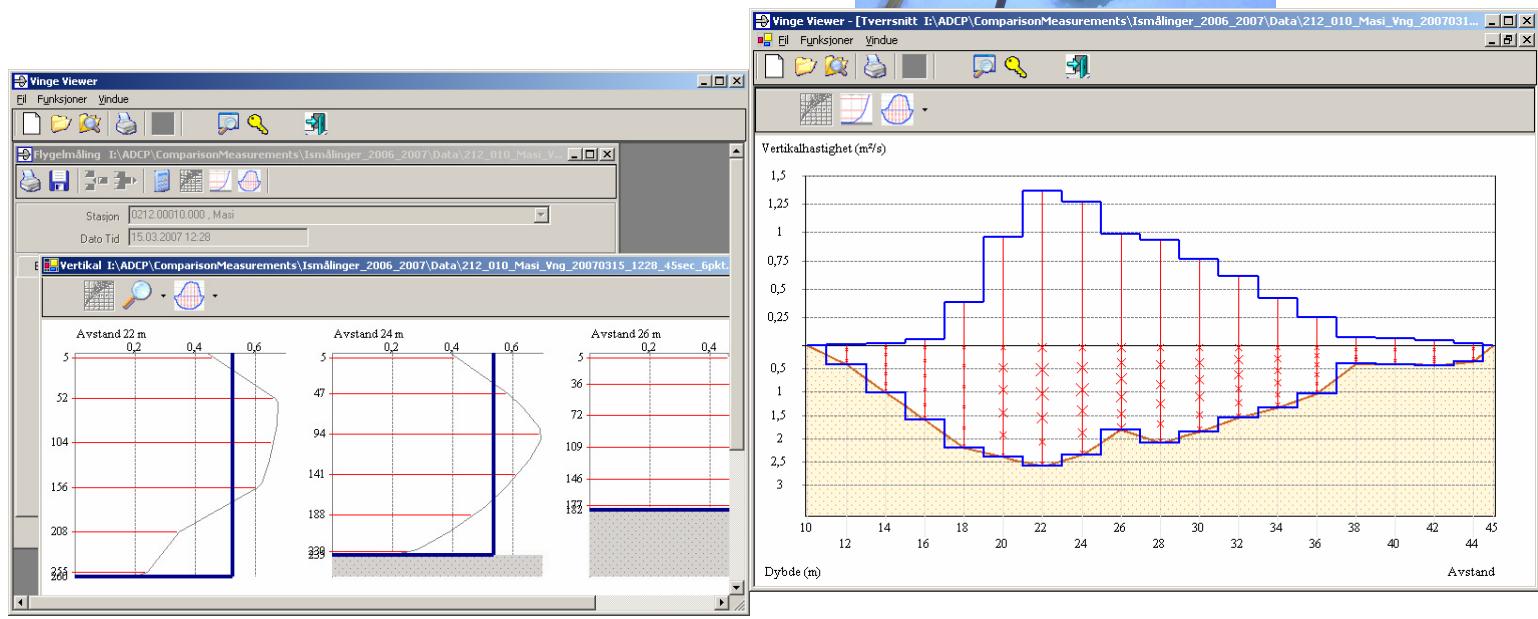
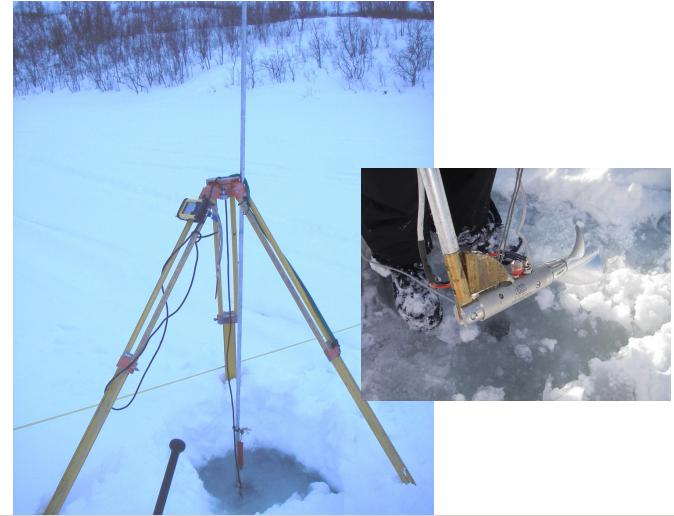
Why compare instruments?

- There will be differences from measurement to measurement, and from instrument to instrument
 - If there is a systematic difference for different instruments, it must be documented
- What if...
 - *"Climate report saying winter-runoff from Norway has increased by 5% !!!"*
 - ...while we just started using other instruments

This has not happened, but it might

Mechanical Current Meter

- Horizontal axes propeller
Ott C-31, PDA, Vinge
- Vertically: ISO 1, 2, 3, 5 or 6 points
- Horizontally: Mid section method
- Velocity ok $\pm 15^\circ$ (downstream)

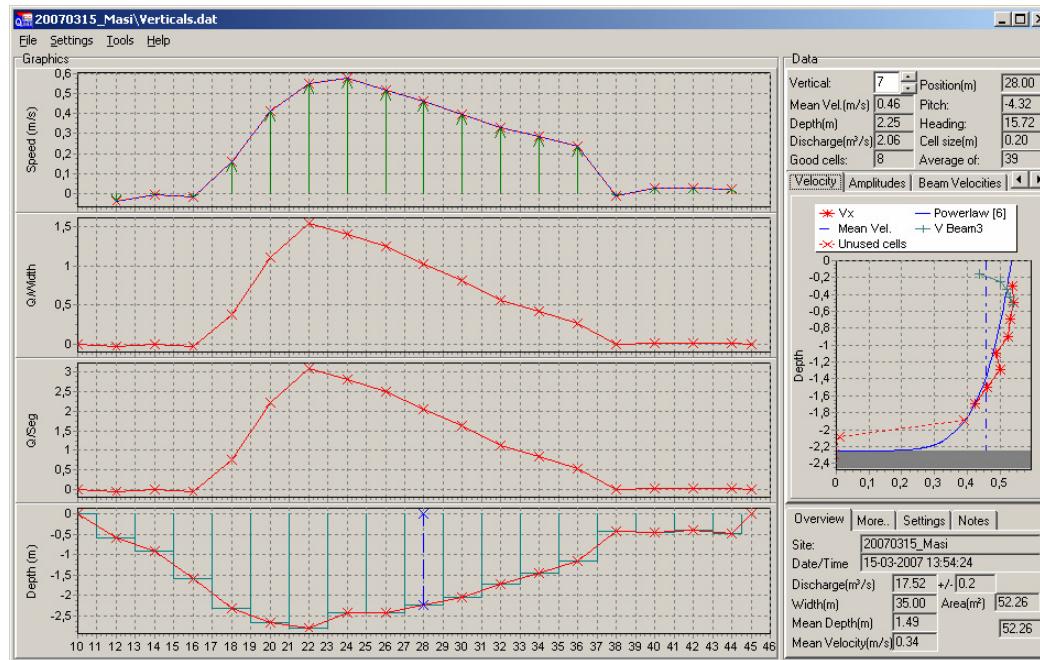




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Acoustic Velocity Profilers (i)

- QLiner, Nortek
- Vertically: Curve fitting to power law vertical velocity profile
- Horizontally: Mid section method
- +/- velocities in one plane





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Acoustic Velocity Profilers (ii)

- StreamPro SxS
Teledyne RD Instruments
- Vertically: No-slip vertical
velocity profile
- Horizontally: Mid section
method
- Uses the velocity
magnitude





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The discharge measurements

- 19 discharge measurements
 - 0,5 – 30 m³/s
 - Not all instruments on all stations
- At least 15-20 verticals per measurement
- Measure with different instruments as simultaneously as possible
- Measure the same verticals
- 45 or 60 sec average interval for mechanical current meter
- 60 and 120 sec average interval for Doppler instruments.



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Instrument and *Instrument*

■ *Instrument*

- Instrument + Post processing + Average interval

Instrument	<i>Instrument</i>	Post processing	Avg. interval [s]	
QLiner	QL-beam123-short	Using beam 3	60	
	QL-beam123-long	Using beam 3	120	
StreamPro SxS	SP-noslip-short	No-slip top & bottom	60	
	SP-noslip-long	No-slip top & bottom	120	
Current meter	CM-2p-short	ISO 2 points	45 or 60	
	CM-6pkt-short	ISO 6 points	45 or 60	



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Data

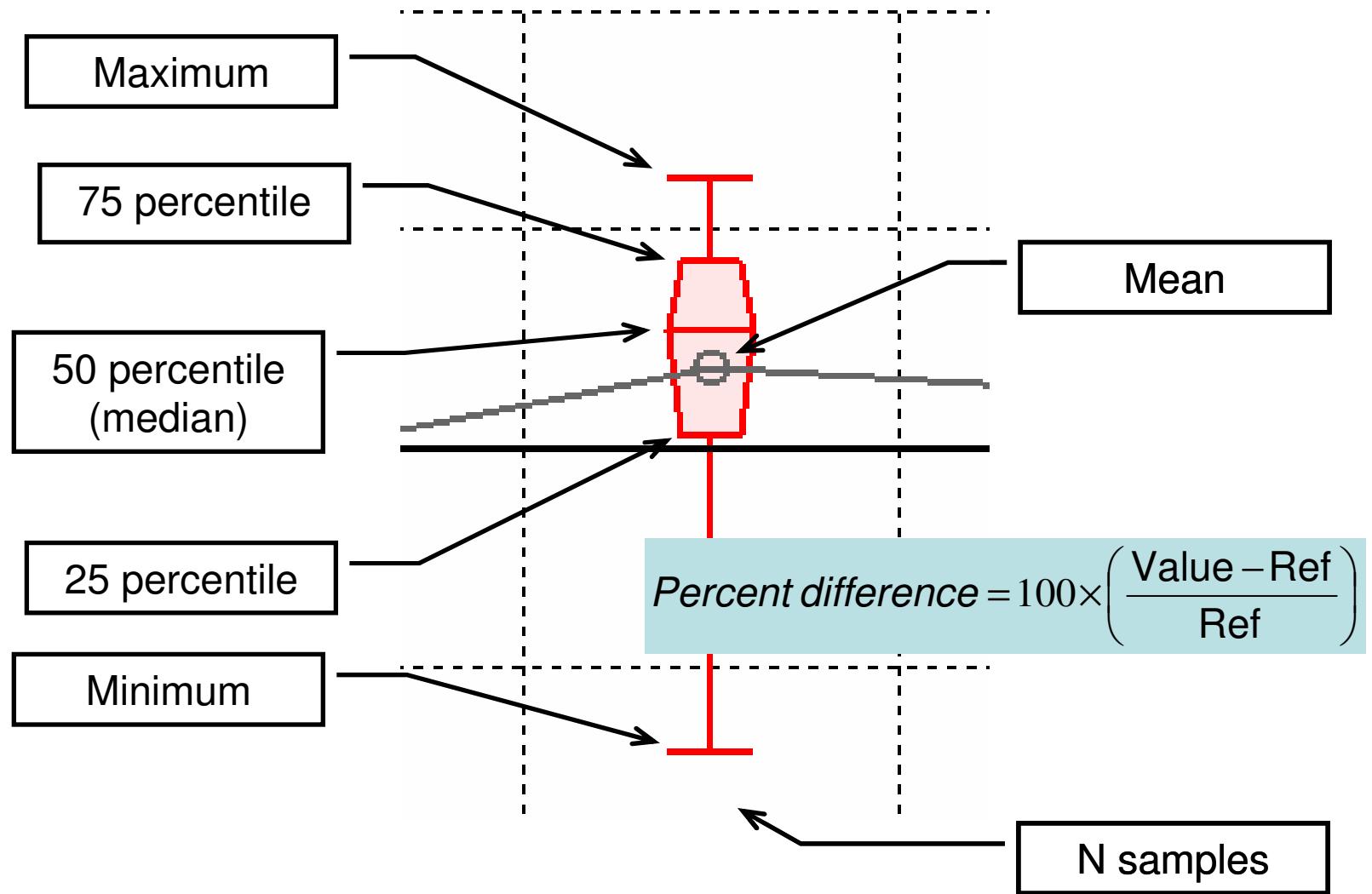
$$\text{Percent difference} = 100 \times \left(\frac{\text{Value} - \text{Ref}}{\text{Ref}} \right)$$

- Value: Velocity, depth, area, discharge.
- Ref: Corresponding value for current meter 2 points per vertical
- *Deviation:* The value of *Percent difference*

- ***Very important note:***
Ref values are not the same as true values.

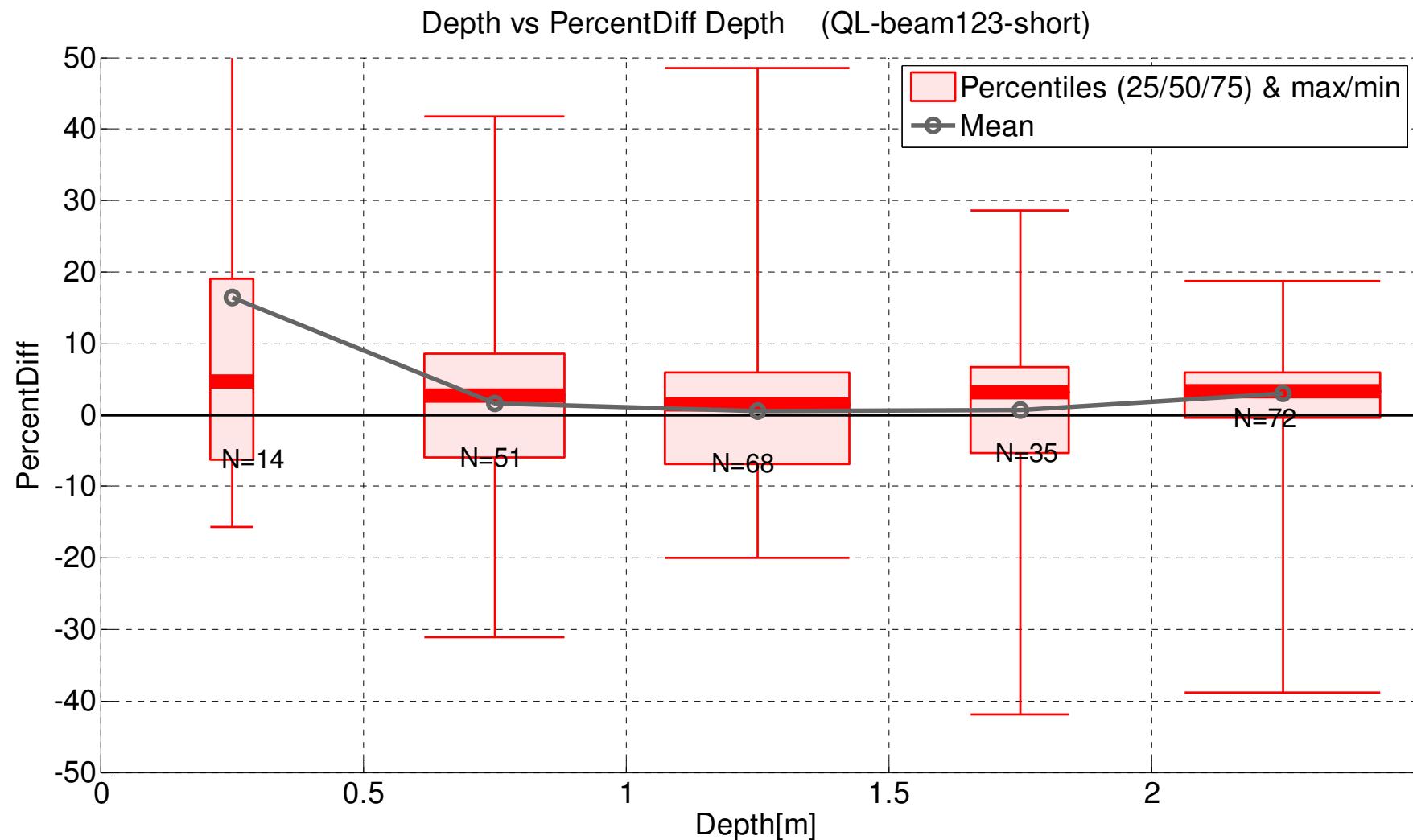


Box-plots



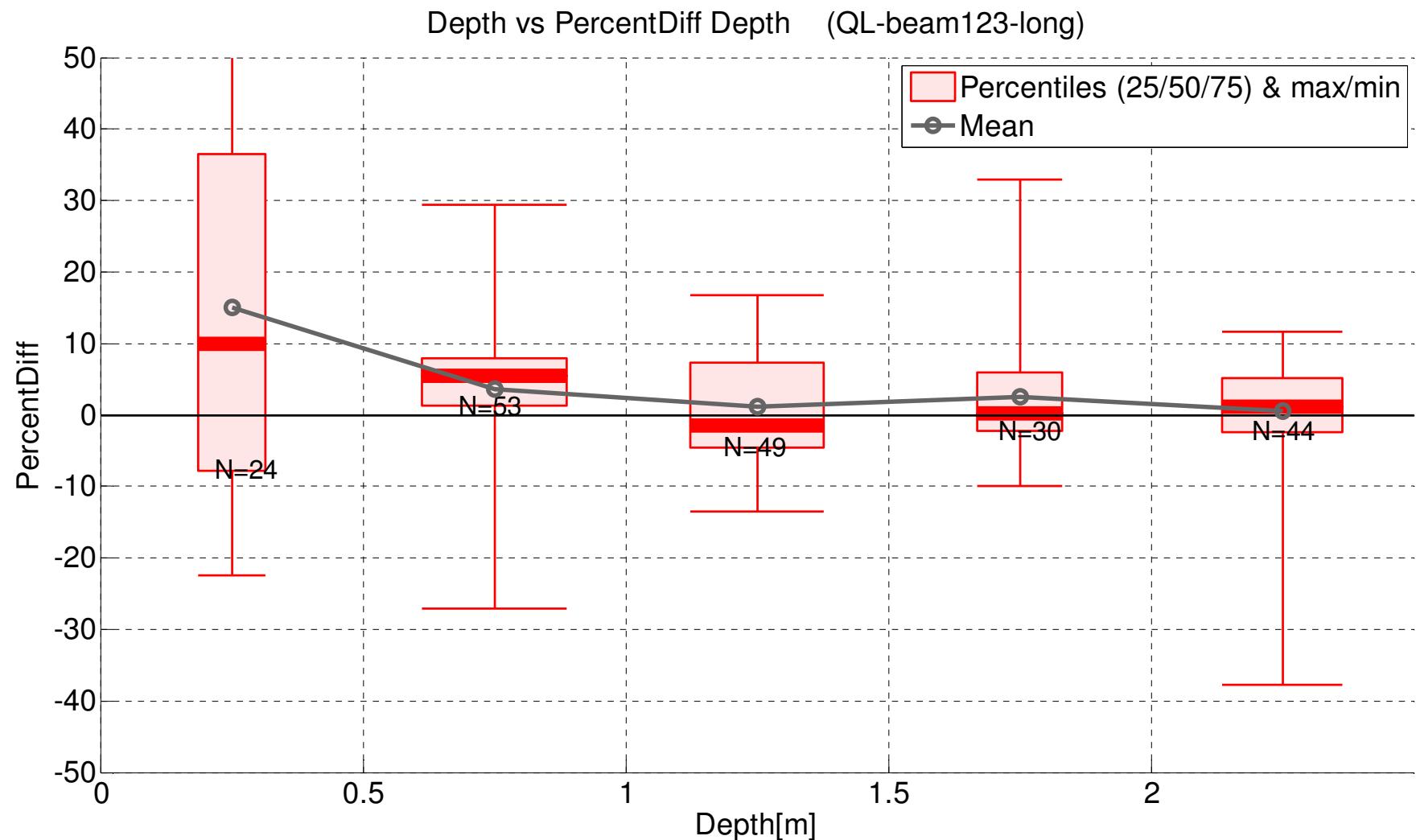


Percent diff for depth QL-beam123-short



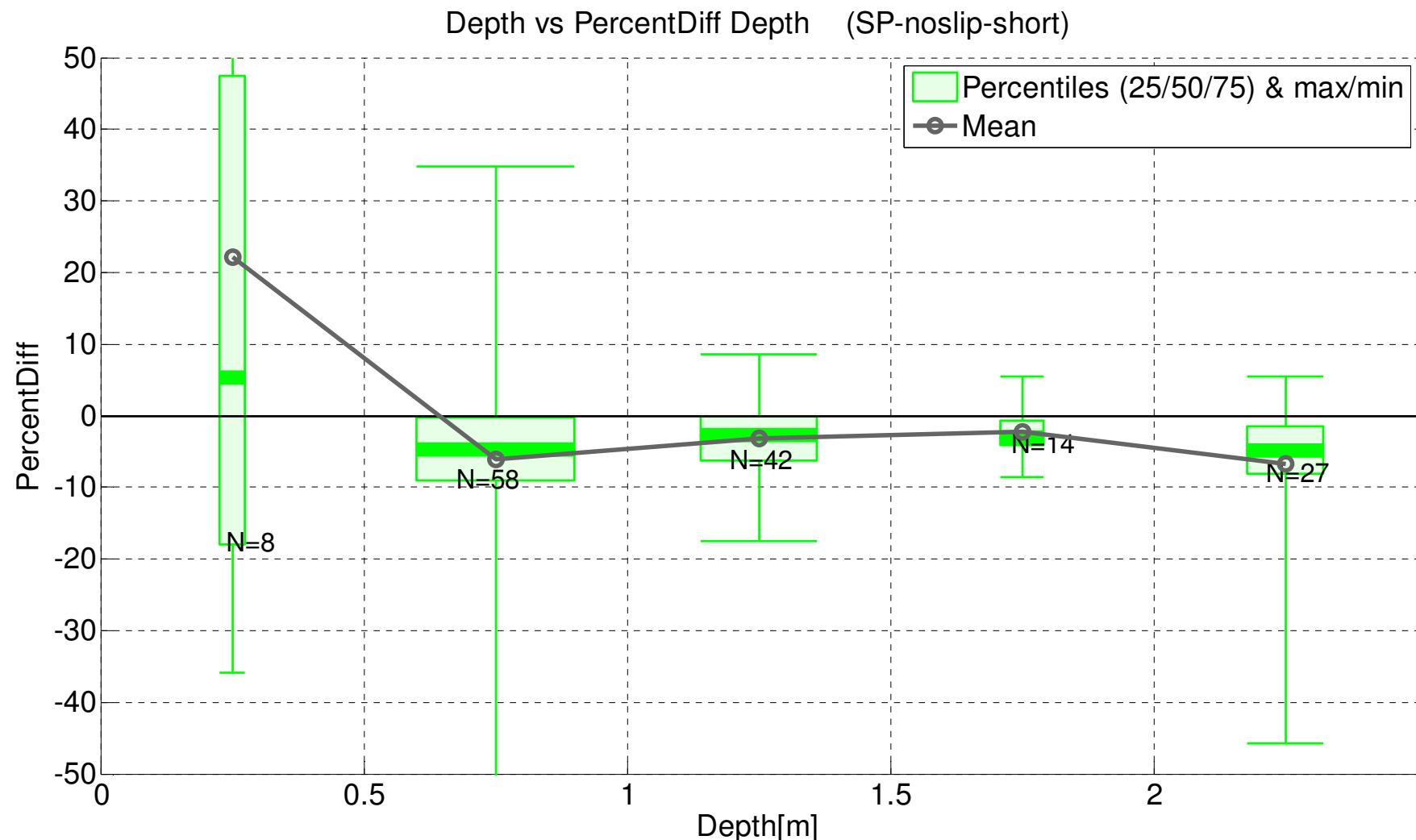


Percent diff for depth QL-beam123-long



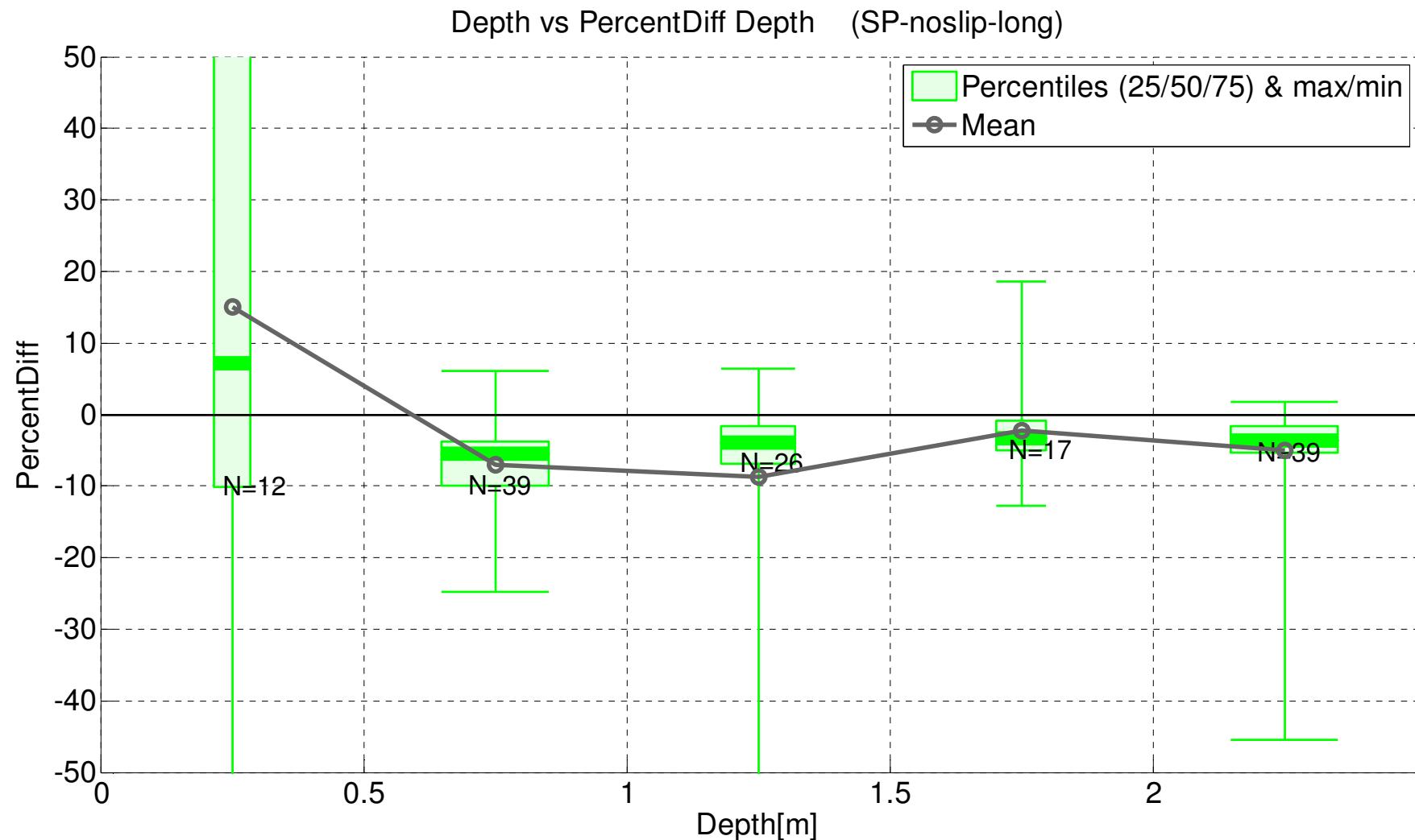


Percent diff for depth SP-NoSlip-short



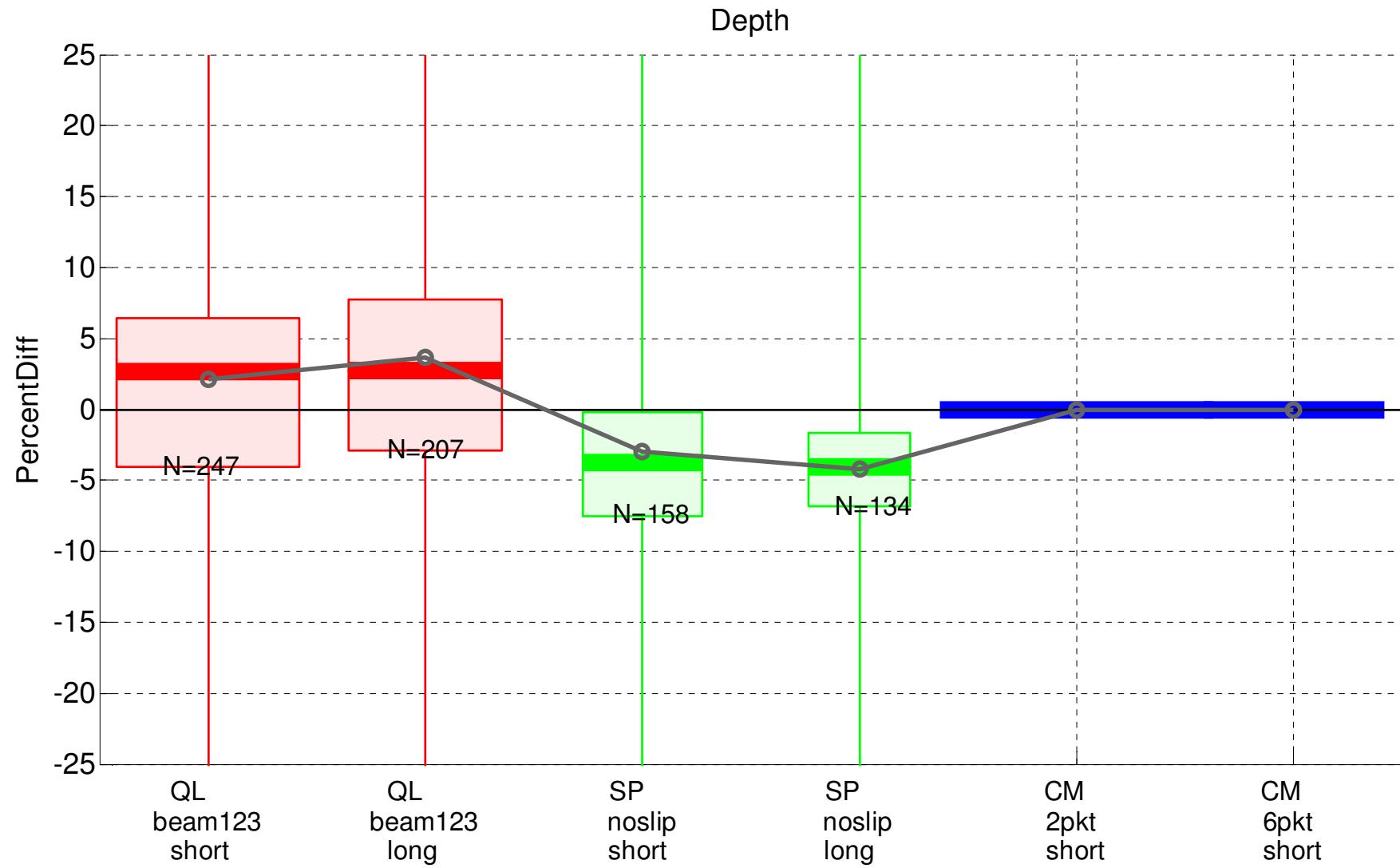


Percent diff for depth SP-NoSlip-long





Percent diff for depth (all verticals)





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Summary depth

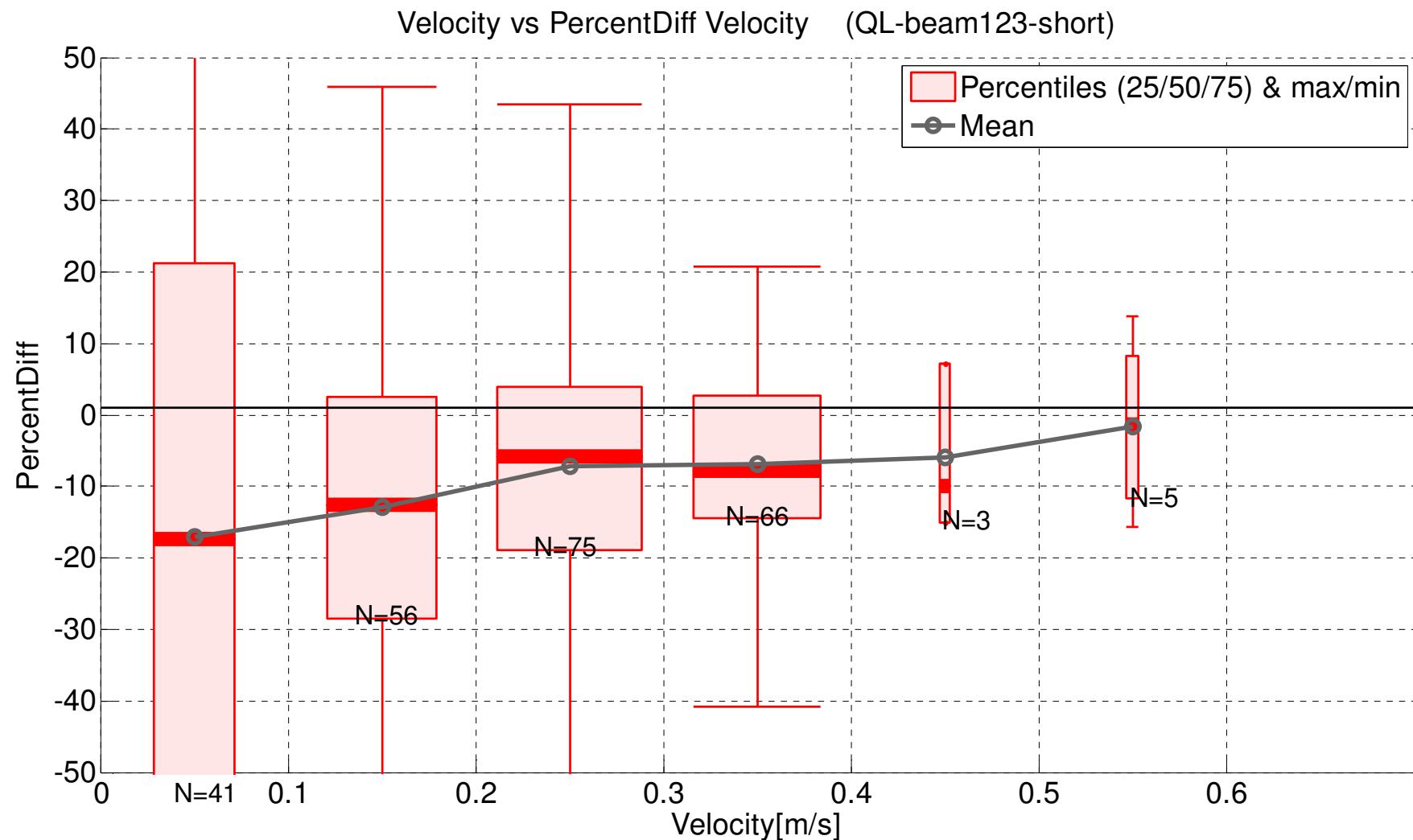
- QLiner measures greater depths than the reference
- StreamPro measures smaller depths than the reference
- Current meter... equal!

- Reference = Current meter (2 points per vertical)

- What about velocity?

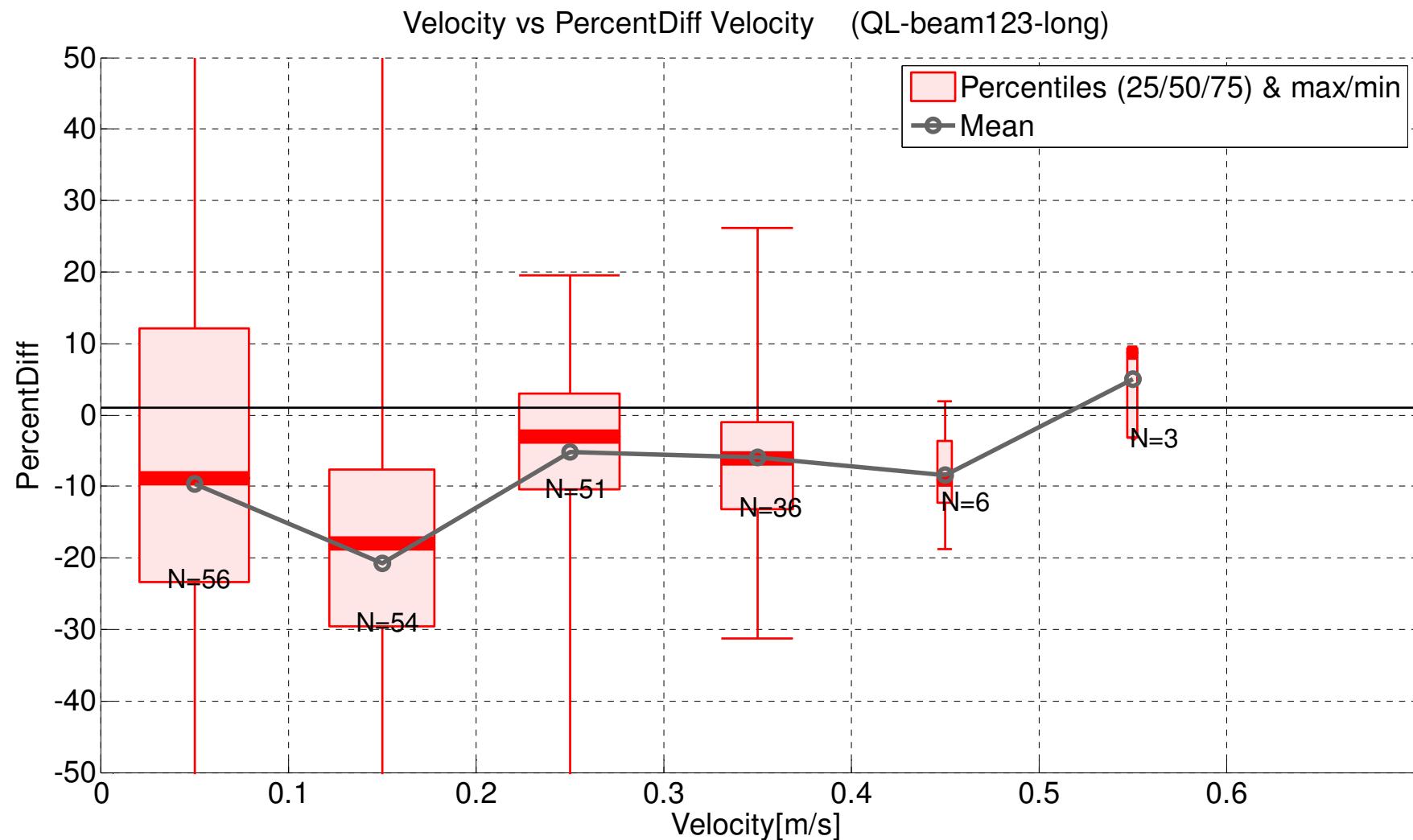


Percent diff for velocity QL-beam123-short



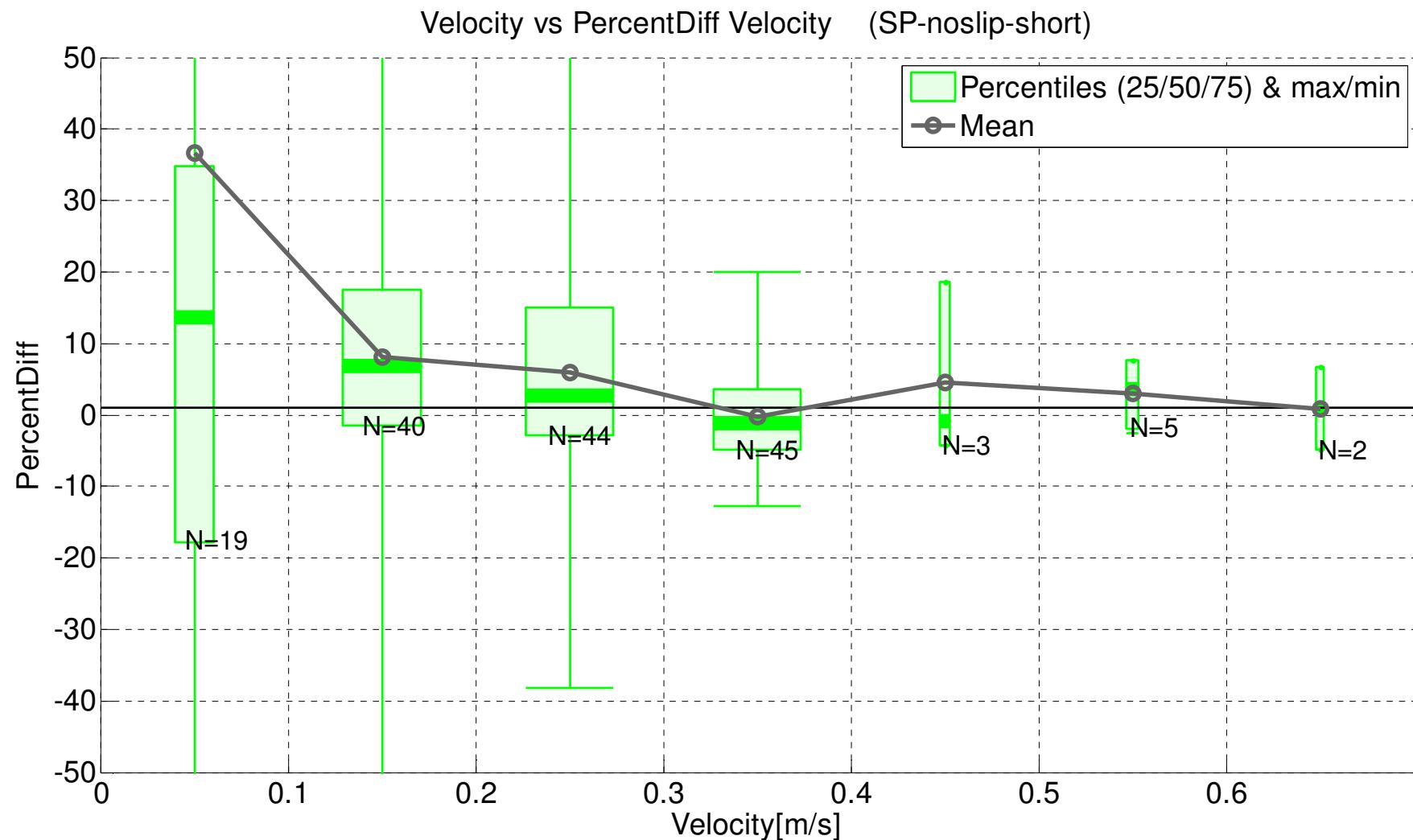


Percent diff for velocity QL-beam123-long



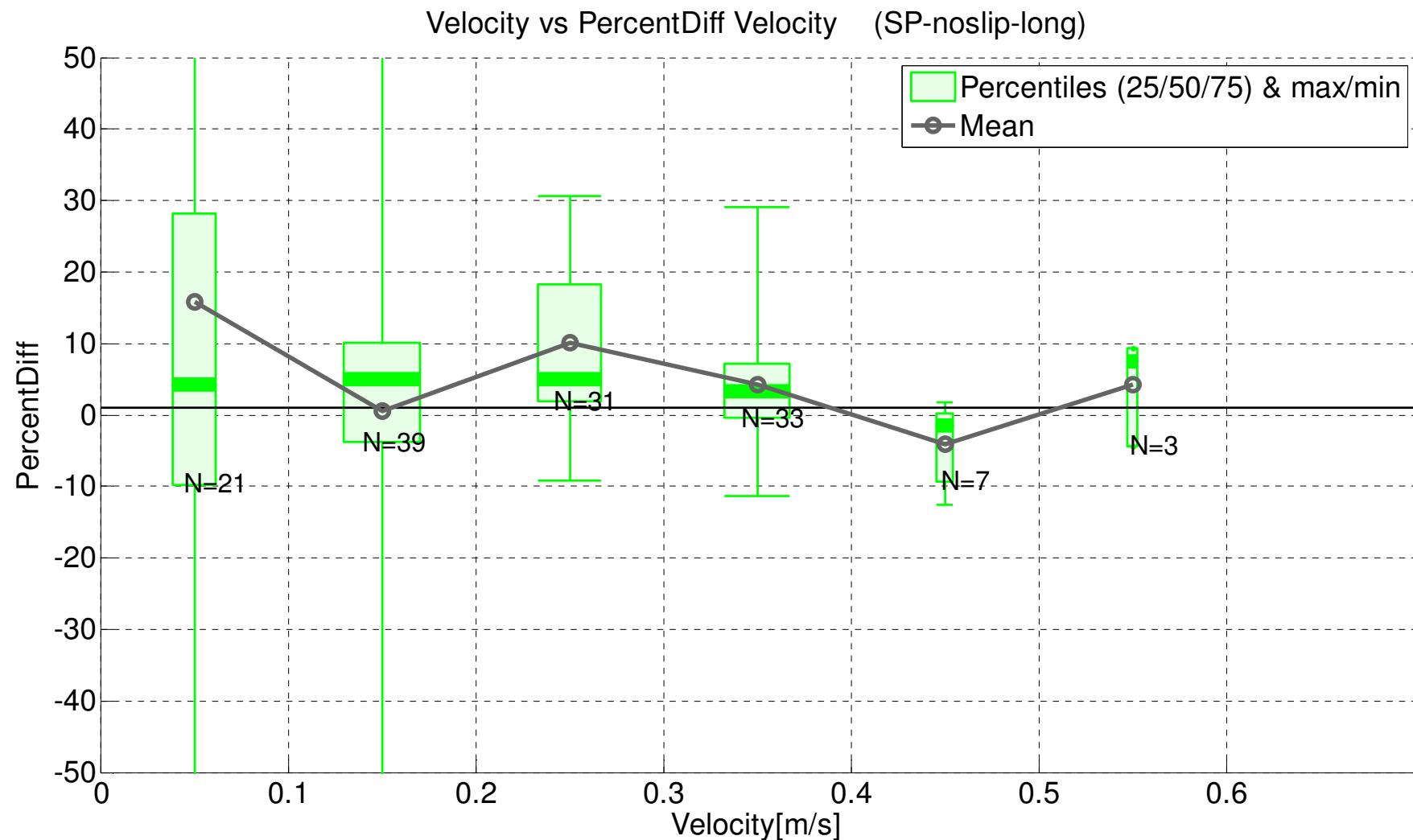


Percent diff for velocity SP-NoSlip-short



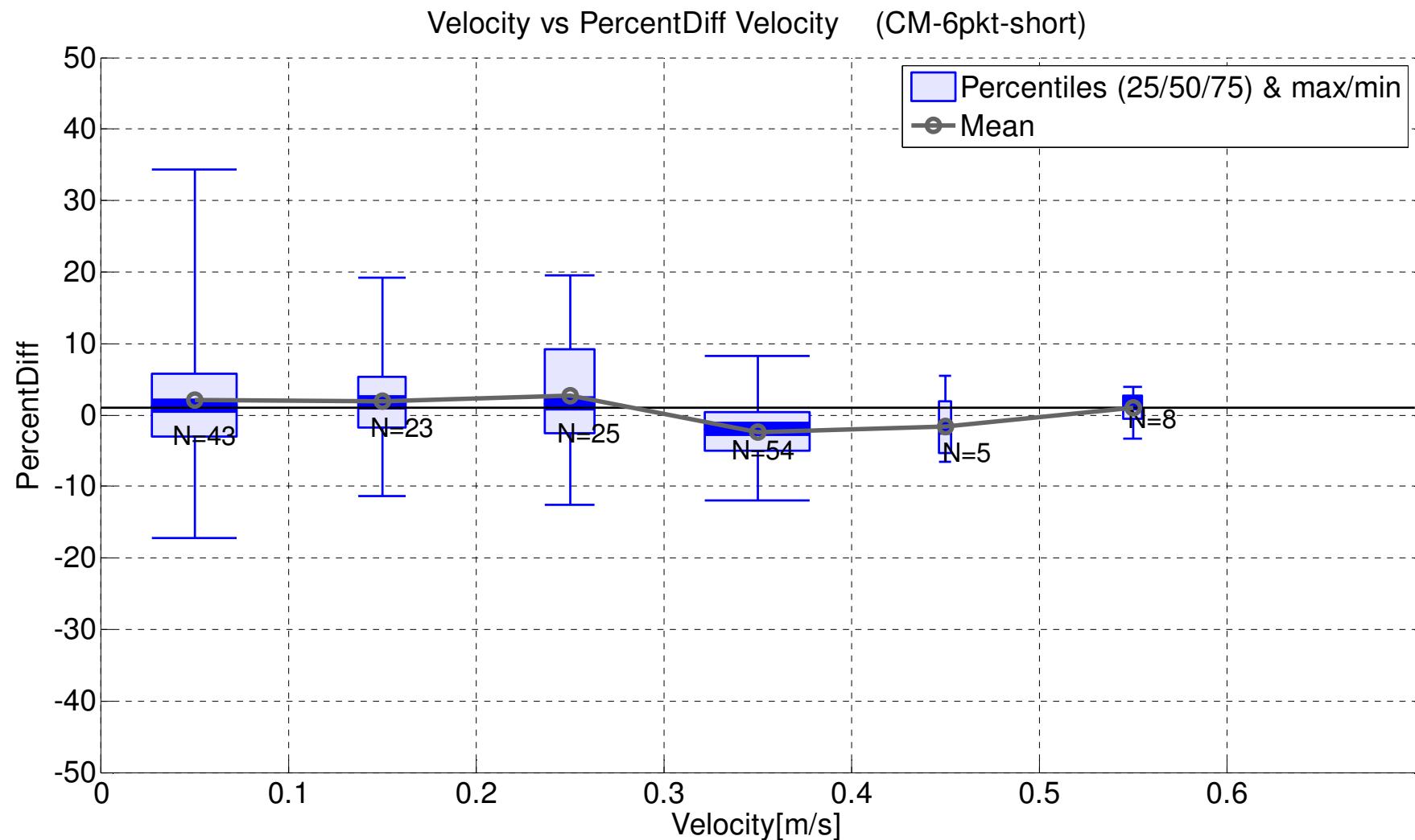


Percent diff for velocity SP-NoSlip-long





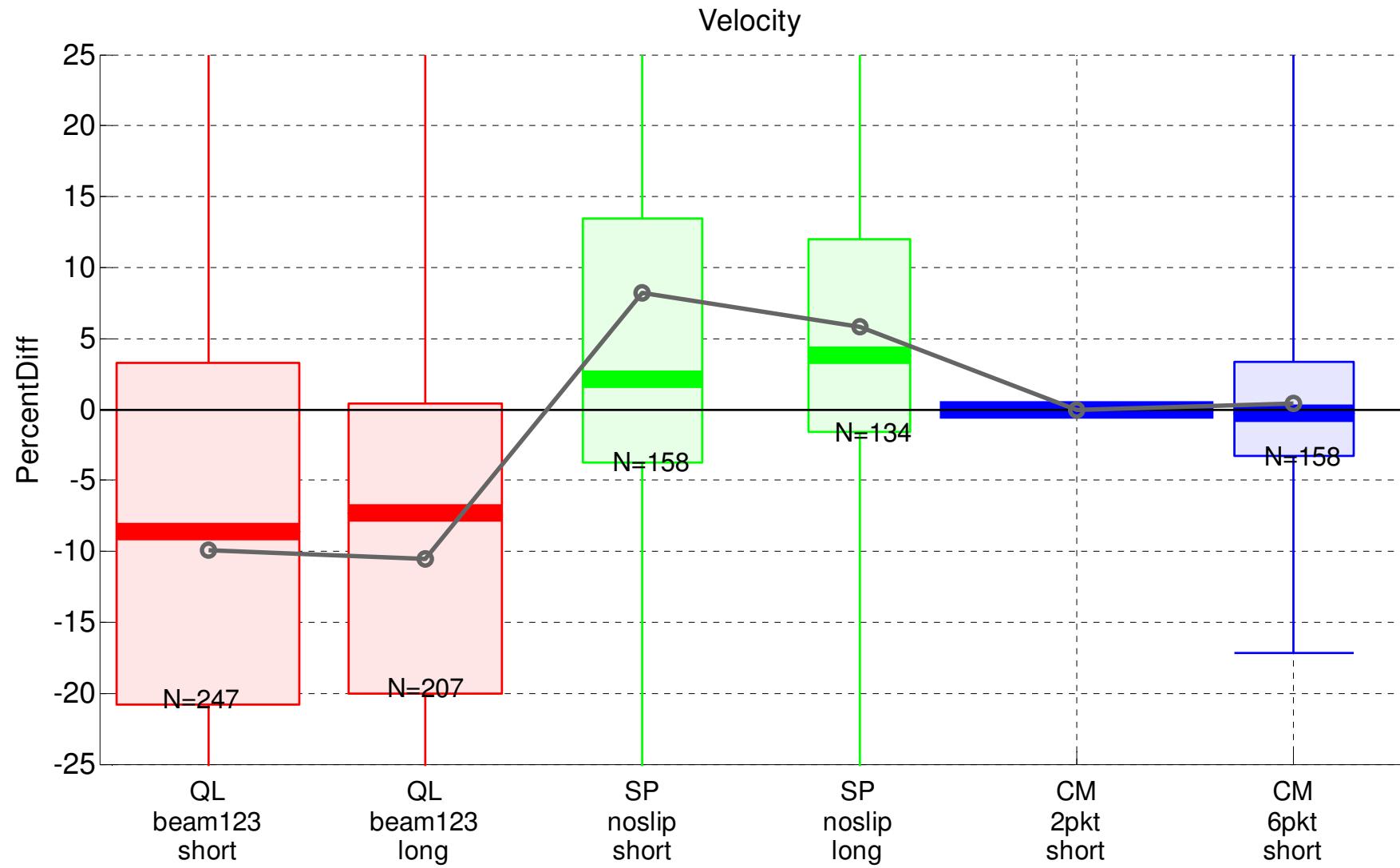
Percent diff for velocity CM-6p-short





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Percent diff for velocity (all verticals)





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Summary velocity

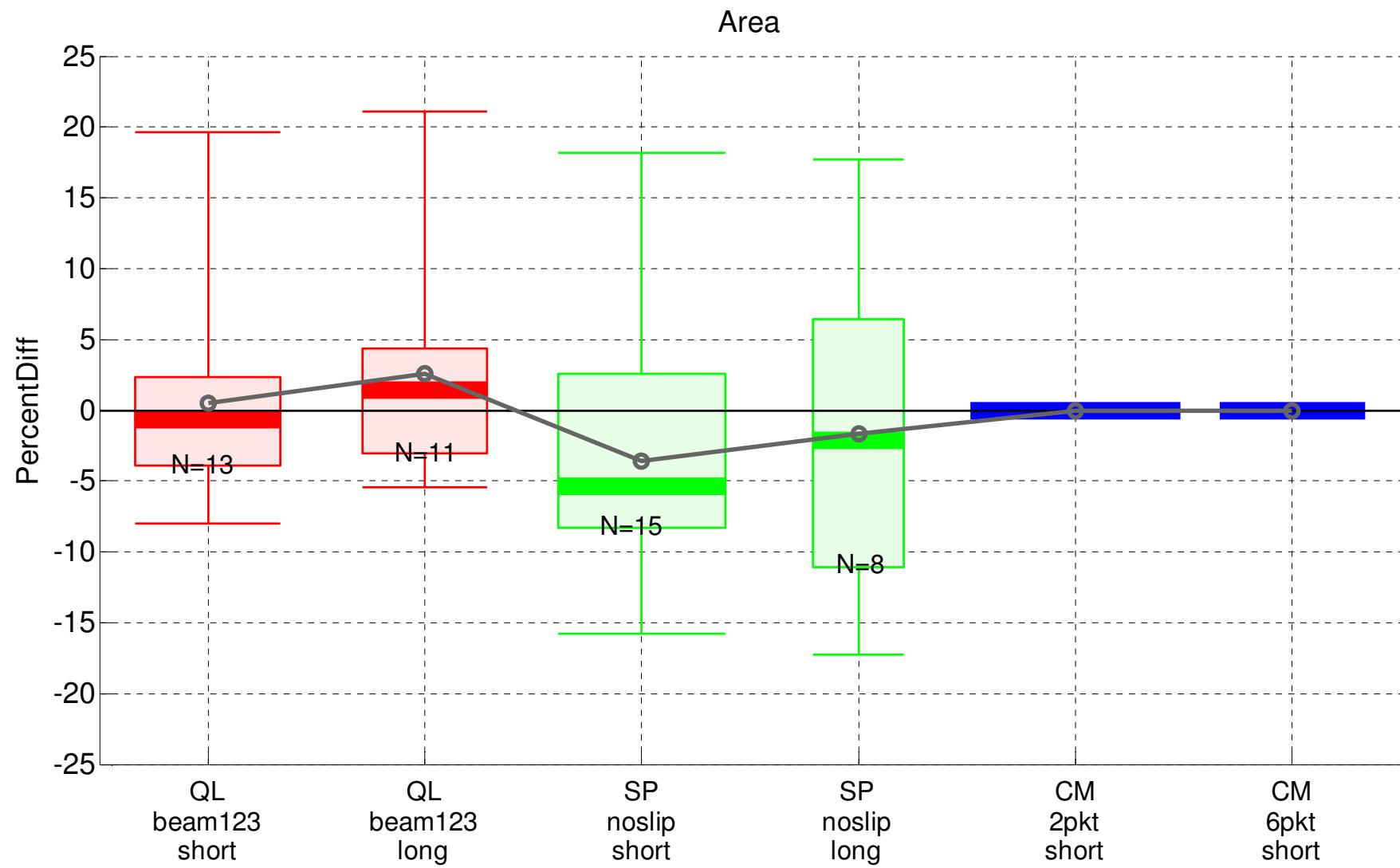
- QLiner measures smaller velocities than the reference
- StreamPro measures greater velocities than the reference
- Current meter (6 points per vertical) is very close to the reference

- Reference = Current meter (2 points per vertical)

- How does this sum up to area and discharge?

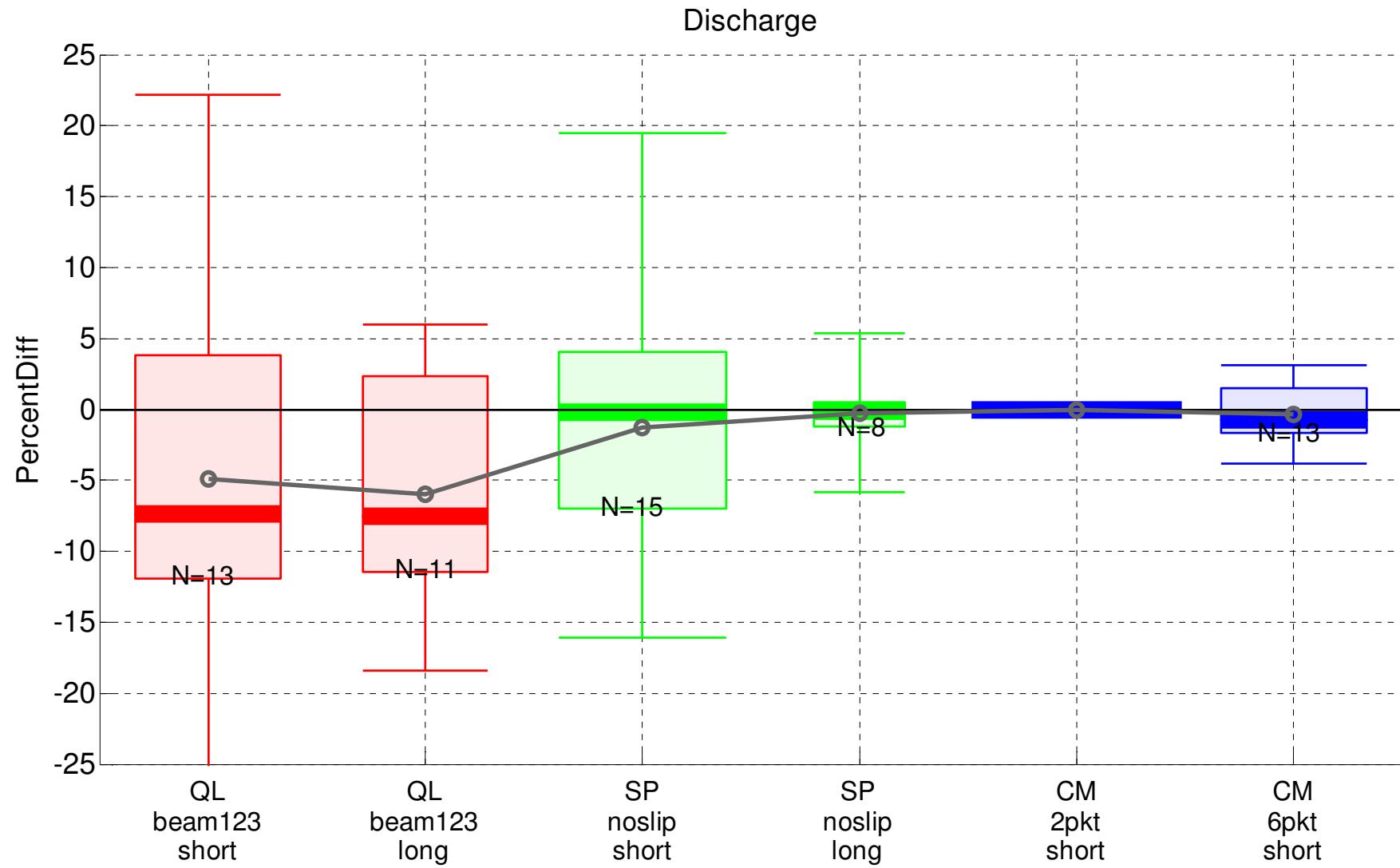


Percent diff for area (all stations)





Percent diff for discharge (all stations)





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Summary area & discharge

- Acoustic instruments:
 - QLiner closest to ref for Area
 - StreamPro closest to ref for Discharge
- Current meter
 - Equal area (off course)
 - Closest of all for discharge
- Reference = Current meter (2 points per vertical)



Conclusion, current meter

- The current meter 2 and 6 points per vertical are closer to each other than any other instrument
- 2 points per vertical is sufficient for measuring under ice

Discharge	N	Percent diff		Deviation	
		Mean	Median	Mean	Median
QL-beam123-short	13	-4,9	-7,4	10,3	8,0
QL-beam123-long	11	-6,0	-7,5	8,1	7,5
SP-noslip-short	15	-1,2	-0,2	6,3	4,4
SP-noslip-long	8	-0,3	-0,1	1,9	0,6
CM-2pkt-short	19	0	0	0	0
CM-6pkt-short	13	-0,3	-0,7	1,7	1,2



Conclusion, StreamPro

- StreamPro's discharge is very close to reference, and only slightly less close than current meter 6 points
- StreamPro measures smaller depths and larger velocities than the 2 points current meter
- Yet, based on the measurements in this study, we can recommend StreamPro, and in particular for the longest averaging interval.

Discharge	N	Percent diff		Deviation	
		Mean	Median	Mean	Median
QL-beam123-short	13	-4,9	-7,4	10,3	8,0
QL-beam123-long	11	-6,0	-7,5	8,1	7,5
SP-noslip-short	15	-1,2	-0,2	6,3	4,4
SP-noslip-long	8	-0,3	-0,1	1,9	0,6
CM-2pkt-short	19	0	0	0	0
CM-6pkt-short	13	-0,3	-0,7	1,7	1,2



Conclusion, QLiner

- QLiner measure less discharge than the other instruments
- It can not be recommended if it is important to measure discharge within 5% off the reference.
- However, on sites with oblique currents and/or back water the QLiner might measure more correctly than any of the two other instruments.

Discharge	N	Percent diff		Deviation	
		Mean	Median	Mean	Median
QL-beam123-short	13	-4,9	-7,4	10,3	8,0
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